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Population biology and ecology of *Crocus heuffelianus* HERB. (*Iridaceae*) in Ukraine

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A b s t r a c t : Results of integrated population biology and ecology studies of *Crocus heuffelianus* HERB. (*C. vernus* (L.) HILL subsp. *vernus* MATHEW) in Ukraine are presented. 7 populations of the East Carpathians (from the lowland to the alpine belt) and 3 populations at the northern boundary of the species area in the Male Polissja have been studied. The taxonomy of the species has been analyzed, its morphology has been elucidated and intra- and interpopulational variation has been found. The area, the ecological and phytocenotic attachment of the species, the structure, productivity and strategy of its populations have been characterized. Seasonal rhythm of development, morpho- and ontogenesis as well as the most important aspects of its reproductive biology (vegetative and seed production, antecology) have been studied. Problems of the species' conservation and prospects of its management are considered.

Introduction

The problem of globally decreasing diversity of plant species can be effectively settled only when a thinking in terms of populations will penetrate into the theory and practice of nature protection. The specific conservation level predominating up to recent times in fact has exhausted itself, being the reason of failure in the organization of the protection of separate plants.

Today it is impossible to develop effective measures to conserve endangered plant species and to provide their further development without studying their population (taxonomic and ecological) structure (KRICSFALUSY 1984; KRICSFALUSY & KOMENDAR 1990; KRICSFALUSY 1991; etc.). Within this context species having area boundaries in regions with great anthropogenic pressure, as, for instance, *Crocus heuffelianus* HERB. (Fig. 1), are of special interest. This is an early-spring and highly decorative plant, a Carpatho-Balkanian subendemic of the European flora, growing in Ukraine at its northern and eastern area boundary. The species is protected in countries of the Carpathian region: Ukraine (Chervona knyha Ukrainskoi RSR, 1980), Slovakia (MAGLOCKÝ 1983), Hungary (VÖRÖS KÖNYV 1990).

To document the present state and to estimate the prospects of conservation of the species in Ukraine we have carried out integrated studies on population biology and ecology of *C. heuffelianus*.

Material and methods

Studies of 10 populations of *C. heuffelianus* carried out between 1990 and 1993 in the East Carpathians and Male Polissja (Ukraine) were used for this paper.

We investigated populations located in the following geographical areas (Fig. 2):

1. Transcarpathian Region:
   - I Uzhgorod District, Tsyganivtsi village (lowland, 200 m above sea level);
   - II Khust District, Shajan village (foothill, 280 m a.s.l.);
   - III Mizhgirja District, Kolochava village (lower mountain belt, 800 m a.s.l.);
   - IV Svidovetsky ridge, mount Dumen (upper mountain belt, 1300 m a.s.l.);
   - V Chornogirsky ridge, mount Menchul Kvasivsky (subalpine belt, 1500 m a.s.l.);
   - VI Chornogirsky ridge, mount Petros (alpine belt, 1940 m a.s.l.);
2. Ivano-Frankivsk Region:
   - VII Nadvirnjansky District, Yablunytsa village (lower mountain belt, 810 m a.s.l.);
3. Lviv Region:
   - VIII Sokal District, Borove village (200 m a.s.l.);
   - IX the same, Dvirtsy village (210 m a.s.l.);
   - X the same, Velyki Mosty (210 m a.s.l.).

A grid of squares (11.6 x 11.2 km) was used as cartographic basis for generalizing chorological information according to the mapping of Middle European flora (EHRENDORFER & HAMANN 1965). The species' ecological characteristics have been compiled using the scales made by ELLENBERG et al. (1991) and LANDOLT (1977). Phytocenotic descriptions and documentation the vegetation units have been carried out in accordance with the principles of the floristic classification (BRAUN-BLANQUET 1964). All plant species names are used according to CHEREPANOV (1981).

For surveying the soil cover in the studied population sites, soil dissections were made and described. Soil types classification was carried out according to the schemes made by RUDNEVA (1960) and GUMENYUK (1972).

The phenological observations were made in accordance with the methods developed by BEIDEMAN (1974).

For studying biomorphological features as well as intra- and interpopulational variation of the species, 25 generative individuals were selected from each population using the principle of randomization and the following morphological characters were studied: 1) plant height, mm; 2) bulbotuber width, mm; 3) bulbotuber height, mm; 4) leaf length, mm; 5) leaf width, mm; 6) number of leaves, pcs; 7) peduncle length, mm; 8) ovary length, mm; 9) perianth tube length, mm; 10) pistil length, mm; 11) petal length of the outer circle of the perianth, mm; 12) petal width of the outer circle of the perianth, mm; 13) petal length of the inner circle of the perianth, mm; 14) petal width of the inner circle of the perianth, mm; 15) stamen filament length, mm; 16) anther length, mm; 17) anther width, mm. For studying the productivity of individuals and populations the following weight parameters (g) have been examined: 1) general plant phytomass; 2) bulbotuber phytomass; 3) phytomass of a leaf; 4) phytomass of leaves; 5) reproductive part phytomass.

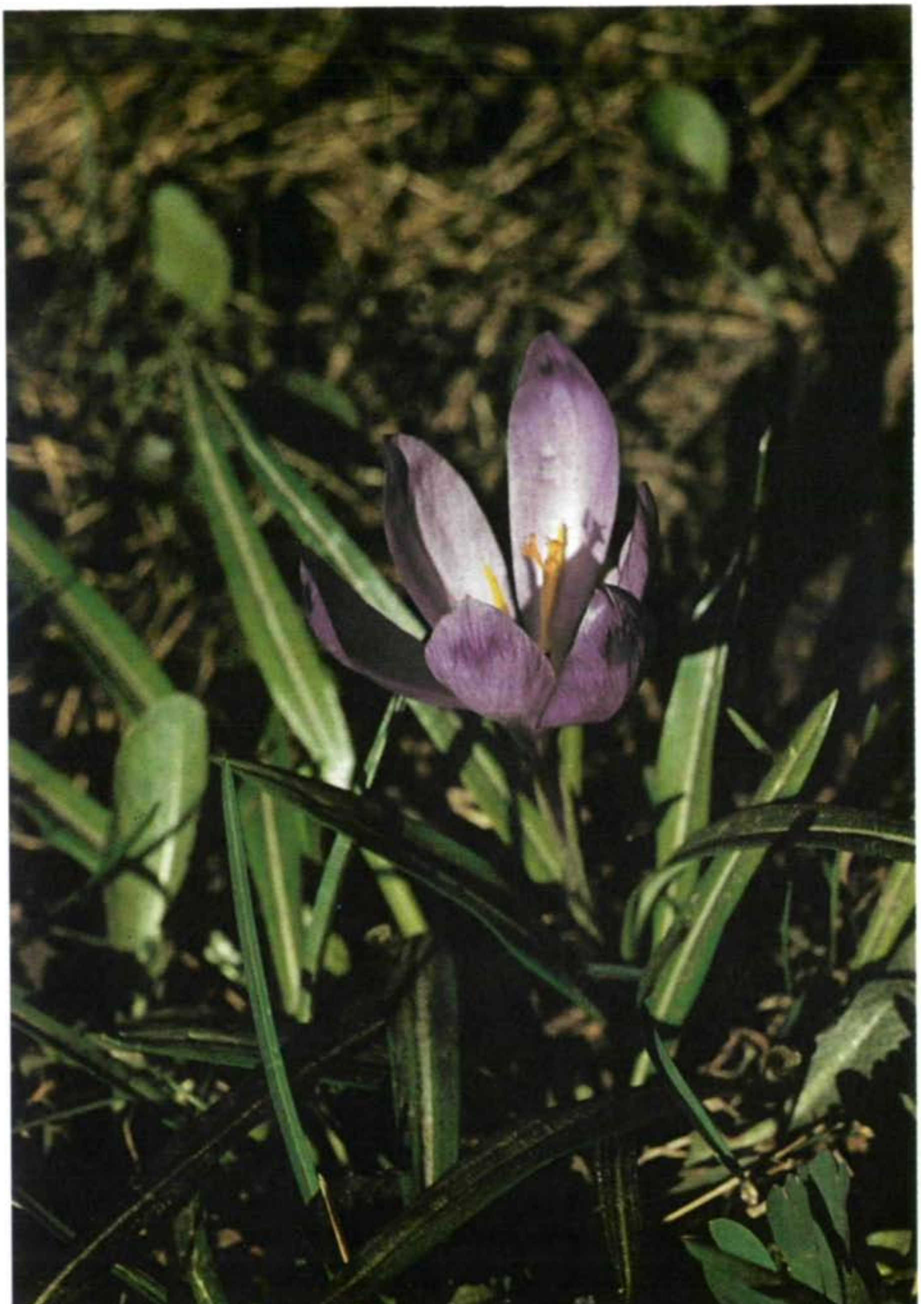


Fig. 1: *Crocus heuffelianus* HERB. 1847

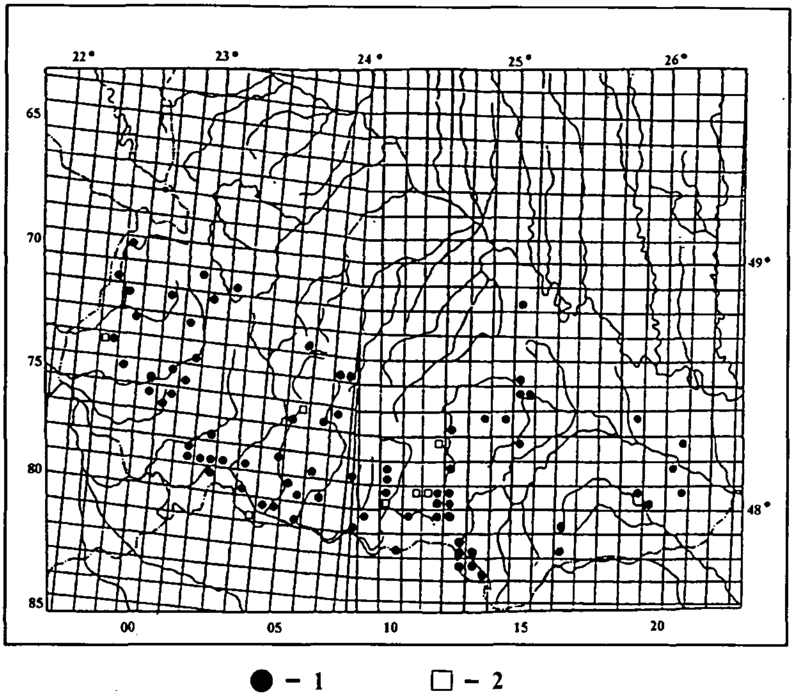


Fig. 2: Distribution of *C. heuffelianus* in the East Carpathians:
1 - known sites; 2 - model populations

The studies of major life cycle, determination of age structure and population density in different ecologocenotic conditions were carried out on transects within a single association site. Biomorphological characteristics of plants of each age group were compiled on the basis of measurements of 10-15 individuals. Age stages were determined according to RABOTNOV's scheme (1950), complemented by SMIRNOVA et al. (1976). Seed productivity was determined according to RABOTNOV (1960) and VAINAGIJ (1974). Vitality population structure was studied according to ZLOBIN (1984).

The obtained numerical data were processed by variation statistic methods (LAKIN 1990 et al.). For each arithmetical mean (X) an error was determined (± Sx), as well as average quadratic or standard deviation (*Sx*) and variation factor *V* (%). Biometric parameters confidence was estimated by the Student criterion (*t*). To state the precision of the studies the index *P* (%) was calculated. To study the nature of interrelations between the characters, a correlation factor (*r*) was estimated. The morphological integration index (ZLOBIN 1984) was calculated according to the formula:

$$I_{\blacksquare} = \frac{B}{\left(n^2 - n\right)/2} \times 100\%,$$

where n is the total number of morphoparameters, B is the number of statistically reliable correlations.

To calculate the index of regeneration (ZHUKOVA 1987) the following formula was used:

$$I = \frac{p + j}{g} \times 100\%,$$

where p denotes shoots, j means juvenile, g - generative individuals. Variation statistic processing of the numerical data has been carried out by means of an IBM PC/AT-386. The caryological studies were carried out by KISH using the method of squash preparations with following acetocarmine staining (PAUSHEVA 1988).

Taxonomy

According to the classification of Magnoliophyta made by TAKHTAJAN (1987), the Genus *Crocus* L. belongs to tribe *Croceae,* subfamily *Ixioideae*, family *Iridaceae* A.L. DE JUSSIEU 1789, order *Liliales*. In the generic system *C. heuffelianus* belongs to subgenus *Crocus*, section *Crocus* (MATHEW 1982). In the genus *Crocus*, as a result of classifying the same taxa as different ranks, from 67 (MAW 1882, 1886, in: SHORINA 1975) to 100 (JÁVORKA 1964) species can be found, while GOLDBLATT (1990) in his new system of *Iridaceae* includes about 80 species in the genus *Crocus*.

For the territory of Ukraine different authors state 8 (FOMIN & BORDZILOVSKY 1950) to 9 (PROTOPOPOVA 1987) *Crocus* species. For Transcarpathia in various "Flora..." and "Determination Key..." there are 3 species - *C. albiflorus* KIT. in SCHULT, *C. banaticus* J. GAY, *C. heuffelianus* (FOMIN & BORDZILOVSKY 1950; FODOR 1974; KUZNETSOVA, MJAKUSHKO 1977; TSVELYEV 1979; PROTOPOPOVA 1987). FODOR (1974) besides typical *C. heuffelianus*, also mentions *C. heuffelianus* var. *csapodyae* HORVAT et JÁV. This variety, described from the only site in Hungary (JÁVORKA 1964) has been proved earlier (PRISZTER 1964) to be identical to *C. tommasinianus* HERB.

C. albiflorus KIT. in SCHULT. has been noted for Transcarpathia first by MARGITTAI (1911, 1923) from the environs of Mukachevo. Later on these data were adopted without a proper critical analysis by the authors of further floristic works. Our studies of all known by now *C. albiflorus* sites in Transcarpathia as well as in Switzerland and Austria made it possible, together with the analysis of herbarium materials and numerous literature sources, to come to the conclusion that this species does not grow in Transcarpathia (Ukraine) (KRICSFALUSY 1995). Under its name populations

of the closely related species 4*C. heuffelianus*, are erroneously noted, where white-flowered individuals occur more often (6-10%) than usually (1-2%). These species distinctly differ from one another morphologically, chorologically, ecologically and caryologically. So it can be finally accepted that *C. albiflorus* should be excluded from the list of Ukrainian flora.

According to PRODAN & NYÁRÁDY (1966) and SOÓ (1973) *C. heuffelianus* has the following intraspecific structure:

1. *C. heuffelianus* var. *Heuffelianus* (*eu-Heuffelianus* NYÁR. 1841), which includes f. *Heuffelianus* [l. *versicolor* SCHUR 1866]; f. *minoriflorus* BORB. ex PRODAN 1939; f. *niveus* (SCHUR) PRODAN & NYÁRÁDY 1966 (*niveus* (SCHUR) SOÓ 1970, *albiflorens* SIMK. 1893, *albiflorus* CRETZOIN 1933, SIMON 1968); l. *concolor* (SCHUR) SOÓ 1970; l. *pictus* (SCHUR l.c.) SOÓ 1970;

2. *C. heuffelianus* var. *scepusiensis* (REHMANN et WOŁ. 1894) BORB. 1902 (*C. babiagorensis* ZAPAŁ. 1906). DOSTÁL (1989) identifies both varieties as subspecies, considering the latter as a taxonomically disputable endemic of the West Carpathians.

Having done his revision of the Genus, MATHEW (1980, 1982) assigns *C.heuffelianus* to *Crocus vernus* agg. complex, which he divides into two subspecies: *C. vernus* subsp. *albiflorus* and *C. vernus* subsp. *vernus*. The latter includes, along with *C. heuffelianus*, *C. scepusiensis* (REHM. ET WOL.) BORB., *C. napolitanus* MORD. ET LOIS. and *C. siculus* TIN.

Morphological Variability

D e s c r i p t i o n : *C. heuffelianus* is a perennial herbatious plant (7.1) 10.1-19.5 (25.1) cm in height. The bulbotuber is round, slightly flattened at the top and bottom, (5.0) 9.8-12.0 (15.0) mm in diameter, (5.0) 7.4-11.0 (13.5) mm in height. It is covered with dark brown tunic made of dry scale-like bottom leaves. There is a very short peduncle (0.8) 2.3-4.0 (6.4) cm long. During the period of fruitage it grows, elongating to a considerable extent. The peduncle is covered with the upper leaf which rises from its base. The leaves are linear, cereal-like (2.0) 2.1-7.1 (10.5) mm in width, with their edges bent down, and a silvery strip along the axis of the whole leaf. There are 2 to 3 leaves (4.7) 7.7-16.6 (22.1) cm in length, they grow and develop completely after the plant flourishing, sometimes attaining more than 20 cm in length. At the base they are enveloped by semi-pellucid bottom leaves. The flowers are actinomorphous, single, violet, rarely white. The perianth is simple, corolla-like. The petals are distinctly concave, hairless inside at the base, obovate, outer ones are (2.5) 3.2-4.3 (5.5) cm in length, (0.8) 1.2-1.6 (2.2) cm in width, inner ones are (2.3) 3.1-3.9 (4.8) cm in length, (0.7) 1.1-1.5 (2.0) cm in width. The upper end of the petal has a V-like dark violet spot. The pistil is orange, (5.6) 7.8-12.0 (14.4) cm in length,

3-carpellary, often longer than the stamens. The ovary is inferior, 3-locular, its length reaches (4.0) 6.3-7.4 (9.5) mm, while flowering it is under ground, and during the fruitage period it is brought by the peduncle above the surface of the soil. The fruit is a 3-locular loculicidal compound capsule; during the process of dissemination it is 5-8 cm above the soil surface. On full seed ripening the capsule becomes dry and cracks downward to form three longitudinal slits of the sutural dorsal type, while the seeds pour out of the capsule. The seeds are rounded, oblong, slightly pointed at both ends, several millimetres in diameter (2-4 mm), dark brown, with the aril.

The flower formula: *P3+3A3+0G($\underline{3}$). In the flower structure we have noted some anomalies, which can be described as follows: *P4+4A4+0G($\underline{4}$), *P5A3+0G($\underline{3}$), *P2+2A(1+1)G($\underline{2}$), *P9A3+0G($\underline{3}$). Obviously, the multiplicity of the perianth parts can increase (prevailing majority of the flowers are abnormal) and decrease. The anomalies essentially concern all the flower parts. Sometimes cuts occur on the petals (mainly external ones).

Flower colour varies within a wide range from dark violet to pure white. Plants with white flowers occur in different populations with varying frequency. This feature was stated also by ARTYUSHENKO & KHARKEVICH (1956) and KOMENDAR & NEIMET (1980). Our observations showed that the numbers of white-flowered individuals vary from single specimens in some populations to several hundred in others. Apart from the flower colour, the white-flowered individuals do not differ from the typical plants at all.

Variation: The analysis of the intrapopulational variation of morphological features (Fig. 3) showed that they are characterized mainly by the medium (V:10.09-19.96%) level of variability (MIHALY 1991). Low variability (V:8.49-10.00%) occurs only in 2 populations (I, III) in 4 features - the ovary length, pistil length, outer circle petal length, inner circle petal length. The most variable parameters (V:20.01-39.07%) are the leaf length, leaf width, number of leaves, peduncle length, inner circle petal width. On the whole, the highest variation of the parameters has been stated in population IV, the lowest - in population I and III.

Some certain regularities can be seen in the nature of the interpopulational variation. Thus, the most often studied parameters (9 from 17) attain their maximum values in population I attached to the lowland areas. The indices gradually decrease with the higher site altitudes. As to the distribution of the minimum values, there is a quite different picture. The minimal values of the features (10 from 17) occur most often in population VII.

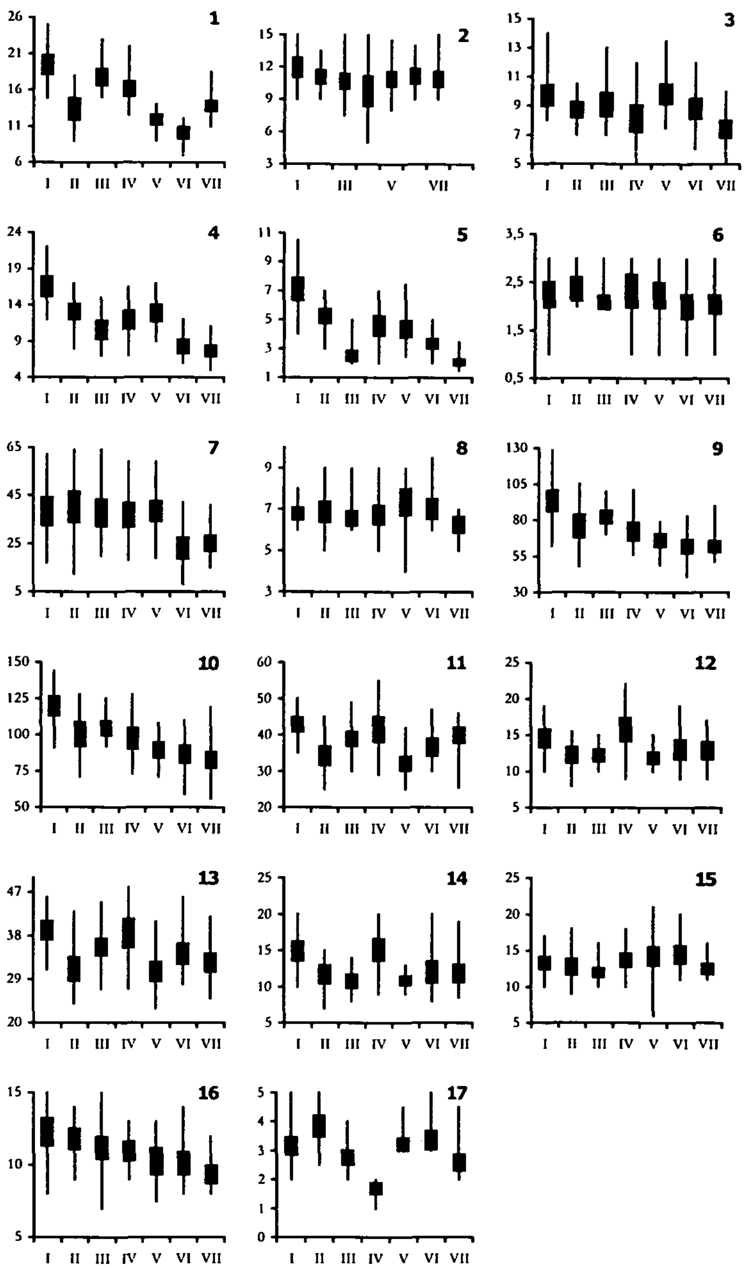


Fig. 3: Intra- and interpopulational variation of *C. heuffelianus* morphometric features: Populations: I - Tsyganivtsi; II - Shajan; III - Kolochava; IV - Dumen; V - Menchul Kvasivsky; VI - Petros; VII - Yablunitsa; 1-17 - features as on p. 2. Graphically presented: arithmetical mean value X, standard deviation *Sx*, variability range *Xmin-Xmax*.

To study the amount of interpopulational differentiation, arithmetic mean values of the features studied were compared by the Student criterion. It has been stated that the following populations differ most: I and VII (in 15 features - 0.882), IV and VII (in 14 features - 0.824), as well as I and III, I and VI, IV and VI (in 13 features - 0.765). The smallest differences have been stated between populations VI and VII (in 6 features - 0.353), populations II and III, V and VI (in 7 features - 0.412), as well as populations II and IV, II and V (in 8 features - 0.471). The analysis of the transgression of standard deviations (Fig. 3) showed that the greatest differences occur between populations I and V, I and VI, I and VII, IV and VII (10 features - 0.588), as well as II and VII (9 features - 0.529). Most similar are the populations II and V (difference in 1 feature - 0.59), VI and VII (in 4 features - 0.235), as well as III and IV, V and VI (in 5 features - 0.294).

For studying the correlational structure of individuals Q-technique, pair correlation coefficients have been calculated. The correlation feature sets can be seen most distincly at the highest level of interrelationship (p = 0.01). There exist certain relations between the following features in all the populations: 1) plant height and perianth tube length (1-9), 2) plant height and pistil length (1-10), 3) perianth tube length and pistil length (9-10), 4) petal length of outer and inner circles of perianth (11-13), 5) petal width of outer and inner circles of perianth (12-14). At the lower levels (p = 0.1 and 0.5) the relationship between the parameters is of a stochastic nature. The greatest number of statistically reliable relations between the features has been found in populations IV (73, morphological integration index is 73%) and VI (55 and 40.4% accordingly). It has been stated earlier that the same populations are closest to the convenient species standard. Thus, the conditions in the sites of populations IV and VI are optimal for *C. heuffelianus* individuals to form their morphostructure (MIHALY 1994).

Summing up the results of the analyses, we can see that they are concerted and allow to differentiate four groups of populations. The first group includes population I, the second one - populations II-V, VIII and IX, the third one - populations VI and VII, the fourth one - population X.

The largest (second) group embraces two lowland Polissian populations and four Carpathian (one foothill, two mountain and one subalpine) populations, characterized by the smallest amount of statistically reliable differences between them. On the same grounds populations VI and VII suffering from unfavourable environmental conditions have been differentiated into a separate group. Populations I and X have been set apart on their own due to the high degree of their differences from one another and from the rest groups of the populations. Population I growing at the lowest area boundary in the conditions of the ecological optimum is noted to have the maximal values of 7 studied parameters. Populations VIII-X are at the northern area boundary of the species in Europe. It can be clearly seen that populations VIII and IX do not differ in their morphometric features from the populations of the central

part of the East Carpathian area. So, the geographical extending of the populations to the north does not affect essentially the morphological status of the individuals. However, the most marked of the Polessian populations is population X, which is characterized by the minimal values of the 6 studied parameters. As a whole, the character of feature variation in all the populations being approximately the same, population X is noted as having the lowest level of their variation which proves that it grows in the ecological-phytocenotic conditions limiting the phenotypic variation of the individuals. In population X the minimal values of the variation coefficient are observed in 3 out of 6 vegetative features, and 5 out of 11 generative features, i.e. almost in 50% cases.

Thus, the results of the analysis allow to suppose that the predominating affect on the morphological aspect of *C. heuffelianus* populations is caused by ecological-cenotic conditions of the environment. The geographical situation of the populations is not the decisive factor (MIHALY 1996).

TSVELYEV (1979) states, that the high mountain samples of *C. heuffelianus* usually have the anthers almost as long as the staminal filaments, while those in the lowland have the anthers 1.5-2 times as long as the staminal filaments. Our results show that in all populations the anthers do not excess the length of the staminal filaments. The ratios of the staminal filaments and anthers (in decimals) in the studied populations are the following: I - 1:0.93; II - 1:0.93; III - 1:0.94;IV - 1:0.80; V - 1:0.72; VI - 1:0.70; VII - 1:0.75. Apparently, we can observe the case of clinal variation which means that with increasing altitude of population sites above sea level the anther length - staminal filament length ratio decreases.

The above mentioned statement made by FODOR (1974) that *C. heuffelianus* var. *csapodyae* (= *C. tommasinianus*) occurs in Transcarpathia, is explained probably by its resemblance to *C. heuffelianus*. Nevertheless, *C. tommasinianus* differs from *C. heuffelianus* lacking of a V-like spot on the top of the petal and in light violet colour of the external side of the perianth outer circle petals. The high degree of colour variation of the *C. heuffelianus* flower, which has been mentioned above, and the great morphological similarity of both species (PRISZTER 1964), makes it possible to identify them as a single species. The natural growing of West Balkan *C. tommasinianus*, attached to the forest areas of Dalmatia, Bosnia-Herzegovina, Chernogoria and Serbia (HAYEK 1931; PRISZTER 1964; MATHEW 1980, 1982), is hardly possible in Transcarpathia. There are even doubts expressed by PRISZTER (1964) as to the autochtonism of the only *C. tommasinianus* site in the south-east part of the Transdanubian region in Hungary. Our observations in the Transcarpathian natural sites of *C. tommasinianus* noted by FODOR (1974) and examination of his herbarium collections have led us to the conclusion that these plants should be classified as *C. heuffelianus*.

Chorology

The whole area of *C. heuffelianus* spreads over Czech Republic, Poland, Slovakia, Austria, Roumania, former Yugoslavia, Albania, Italy and the south-west part of Ukraine (JÁVORKA 1964; MATHEW 1980; RANDJELOVIC et al. 1990). In Ukraine the species is distributed in the Transcarpathian lowland, in the Carpathians, rarely in Volyno-Podillja (FOMIN & BORDZILOVSKY 1950).

According to the scheme of European flora geoelements (MEUSEL et al., 1965) *C. heuffelianus* belongs to Carpatho-Balkanian plants. MALYNOVSKYJ's data (1980) show that the species belongs to the mountaneous element of flora with the European type of area, and is a part of the East Carpathian-Balkanian distribution group occuring, besides the Balkans, only in the East and partly South Carpathians. According to KLEOPOV (1990), *C. heuffelianus* is an Illyrian (Balkanian) element in the Ukrainian flora.

C. heuffelianus distribution at the eastern area boundary in Podillja was described by MELNIK (1993), stating 4 localities for this region and 3 localities for the Volyn' highland.

The first recorded data of *C. heuffelianus* distribution in the East Carpathians can be found in the studies by HERBICH (1859, 1860), REHMANN (1868, 1873), KNAPP (1872), WAGNER (1876), ZAPAŁOWICZ (1889, 1906), MARGITTAI (1911, 1923, 1935, 1937), HAYEK (1916), SZAFER et al. (1924), DOMIN (1929), DEYL (1940), BOROS (1944), PAWŁOWSKI & WALAS (1948), as well as in further researchers' papers (POPOV 1949; ARTJUSHENKO & KHARKEVICH 1956; FODOR 1956, 1974; KOMENDAR & NEIMET 1980; MIHALY 1995; etc.).

On the basis of the critical processing of the herbaria data of Uzhgorod (UU), Lviv (LW), Chernivtsi (CHER), Bratislava (SLO), Prague (PRC) and Cluj (CL) universities, Institutes of Botany of the Ukrainian NASc. (KW) and Polish ASc. (KRAM), Natural History Museums of Lviv (LWS) and Sibiu (SIB), literature sources and our own field observations we have produced a grid map of *C. heuffelianus* distribution in the region (Fig. 2), including 105 localities, 8 of which have been found for the first time.

List of *C. heuffelianus* localities:

Transcarpathian region:

Uzhgorod District: - Tsyganivtsi v. - 22.03.1930, BUČEK (CL, PRC); 12.03.1992, MIHALY (UU); - Strypa v. (GRABAR 1956); - R. Guta v.- 30.03.1972, DUDAS (UU); - Dubrovka v. - 23.03.1980, KRICSFALUSY (UU); - Lazy v. - 8.03.1990, FODOR (UU);

Mukachevo District: - Mukachevo - 05.1917, MARGITTAI (CL); 19.03.1927, MARGITTAI (PRC); - Fornos v. - 05.1920, MARGITTAI (CL); - Pavshyno v. (MARGITTAI 1923); - N. Vyzhnytsja v. - 30.04.1949 (LWS); - Stanovo v. - 19.03.1973, GAZUDA (UU); - Berezynka v. (DROHOBETSKAJA 1982); - Chynadijevo v. - 17.03.1993, KRICSFALUSY (UU);

Vynogradiv District: - Korolevo v. - 12.03.1936, ZAPLETALEK (CL, PRC, SLO); - Vynogradiv - 10.03.1931, PULCHART (PRC); 28.03.1936, MARGITTAI (CL); 29.03.1957, VAJNAGY (LWS); 20.05.1978, SARCADY (UU); - V. Kopanja v. - 18.03.1977, DANKAJ (UU); - Oleshnyk v. (KOMENDAR & NEIMET 1980); - Pushkinovo v. (KOMENDAR & NEIMET 1980); - Salanky v. (KOMENDAR & NEIMET 1980);

Svaljava District: - Pasika v. - 04.1926, MARGITTAI (CL, PRC); - Uklyn v. - 26.03.1979, KRICSFALUSY (UU);

Perechyn District: - mount Rivna - 20.05.1978, KASINETS (UU); - Dubrynychi v. - 17.03.1980, PENYAK (UU);

Tyachiv District: - Bushtyno v. (MARGITTAI 1923); - N. Mokra v. - 05.1927, ZLATNIK (CL - Herb. SOÓ, PRC, SLO); - Krasna ridge, mount Klymova - 22.05.1955, VAJNAGY (LWS); - Krasna ridge - 20.07.1932, LÁSKA (PRC); - Bedevlja v. - 23.03.1957, VAJNAGY (LWS); - Ganychi v. - 16.04.1963, VAJNAGY (LWS); - S. Lug v. - 23.03.1973, DUDLA (UU); - R. Pole v. - 25.03.1977, BORTOS (UU); - V. Bychkiv (KOMENDAR & NEIMET 1980); - Svidovetsky ridge, mount Apecka (DROGOBETSKAJA 1982); - Neresnytsja v. (KOMENDAR, KRICSFALUSY & MARYCH 1982); - Uglya v. - 25.03.1987, KRICSFALUSY (UU);

Rachiv District: - Chornogirsky ridge, mount Balcatul (ZAPAŁOWICZ 1889); 07.07.1978, KRICSFALUSY (UU); - Chornogirsky ridge, mount Berbeneska (ZAPAŁOWICZ 1889); - Chornogirsky ridge, mount Turkul (ZAPAŁOWICZ 1889); - Chornogirsky ridge, mount Tomnatek (ZAPAŁOWICZ 1889); - Chornogirsky ridge, mount Hoverla (REHMANN 1873; ZAPAŁOWICZ 1889); - 04.1928, TULIGLOWICZ (LWS); - Chornogirsky ridge, mount Petros (HAYEK 1916); - 09.06.1955, SHYSHOVA (LW); 06.1967, CHALAK (LW); - Chornogirsky ridge, mount Pop Ivan (REHMANN 1873; ZAPAŁOWICZ 1889; HAYEK 1916); - 06.1933 (PRC); - 20.05.1965 (UU); - Chornogirsky ridge, mount Chorna Gora (REHMANN 1873); - Svidovetsky ridge, mount Terentyn - 05.1878, VAGNER (SIB - Herb. Fuss); Svidovetsky ridge, mount Dumen - 14.05.1937, PULCHART (PRC); - Svidovetsky ridge, mount Mala Blyznytsja (DOMIN 1929); - 2.06.1930 (PRC); - Svidovetsky ridge, mount Dragobrat - 12.05.1940, SOÓ (CL - Herb. SOÓ); - Svidovetsky ridge, mount Blyznytsja - 31.05.1948, MALYNOVSKYJ (LWS); (FOMIN & BORDZILOVSKYJ 1950); - Chornogirsky ridge, mount Breckul - 01.07.1956 (LWS); - Chornogirsky ridge, mount Sheshul - 04.06.1957, VAJNAGY (LWS); 10.06.1965, TRACH (LW); - Chornogirsky ridge, mount Konetz-Polonina - 05.1882, VAGNER (PRC); - Chornogirsky ridge, mount Menchul Kvasivsky - 26.05.1965, GURS (LW); 23.05.1988, KRICSFALUSY (UU); 9.05.1990, MIHALY (UU); (MALYNOVSKYJ 1980); - Svidovetsky ridge, mount Kobyla - 21.03.1979, HAJNAL (UU); - Marmaroski Alpy ridge, mount Pop Ivan (DEYL 1940);

Mizhgirja District: - Gorgany ridge, mount Popadja - 05.1947 (LWS); - Kolochava v. (KOMENDAR & MIHALY 1994);

Khust District: - Dragovo v. (MARGITTAI 1923); - Veljatyno v. - 20.03.1979, DULKAJ (UU); - Kireshi v. - 18.03.1982, KRICSFALUSY (UU); - Shajan v. - 15.03.1988, KRICSFALUSY (UU); 01.04.1992, MIHALY (UU);

Velykobereznjansky District: - Myrcha v. - 16.04.1979, HANYCH (UU); (KOMENDAR & NEIMET 1980);

Irshava District: - N. Bolotne v. - 08.03.1979, KURUC (UU); - Vilychivka v. - 10.03.1979, KURUC (UU);

Volovec District: - N. Vorota v. - 15.04.1992, MIHALY (UU);

Lviv Region:

Skole District: - Klimets v. (ÀRTYUSHENKO & KHARKEVICH 1956);

Nesteriv District: - Bojanets v. - 17.04.1963, PELECH (LW);

Sokal District: - Velyki Mosty - 1877, SCHAUER (LWS); 1.04.1986, ZAHULSKYJ (LW); - Sokal - 21.04.1911, SZAFER (LW, LWS, KRAM);

Brody District: - Brody - 6.05.1960 (LW);

Ivano-Frankovsk Region:

Nadvirna District: - Chornogirsky ridge, mount Pozhyzhevska (REHMANN 1873) - 3.06.1928 (KW); 3.06.1958, JERMACHENKO (LWS); 10.07.1962, BEDEJ (LW); 25.05.1964, DOBROCHAEVA (KW); 21.05.1961, SOLODKOVA (CHER); - Rafajlovo v. - 1.05.1941, HRYN (KW); - Vorokhta v. - 20.05.1965, POZHELSKA (LWS); - Mykulychyn v. (REHMANN 1873);

Kosiv District: - Bereziv v. - 04.1933 (LWS); - Jablonow v. (HERBICH 1860; KNAPP 1872); - Pistyn v. (KNAPP 1872);

Verkhovynsky District: - Chornogirsky ridge, mount Spyci (REHMANN 1868; KNAPP 1872);- 9.07.1933, MICZYNSKI (KRAM); - Chornogirsky ridge, mount Turkul - 15.07.1933, PAWLOWSKI (KRAM); - Chornogirsky ridge, mount Malyj Tomnatek (FOMIN & BORDZILOVSKYJ 1950); - Chornogirsky ridge, mount Kostrycha (FOMIN & BORDZILOVSKYJ 1950); - Chyvchynsky ridge, mount Skorushnyj (ZAPALOWICZ 1889); (CHER); - Chyvchynsky ridge, mount Chyvchyn (PAWLOWSKI & WALAS 1948) - 1.06.1936, MADALSKI (LWS); - 1.06.1936, PAWLOWSKI (KRAM); - 13.06.1958 (LWS); - Chyvchynsky ridge, mount Suligul - 2.06.1936, PAWLOWSKI (LWS, KRAM); - Chyvchynsky ridge, mount Albin (PAWLOWSKI & WALAS, 1948); - Chyvchynsky ridge, mount Baltagon (PAWLOWSKI & WALAS 1948); - Chyvchynsky ridge, mount Palenica (PAWLOWSKI & WALAS 1948); - Chyvchynsky ridge, mount Budyjowska Wielka (PAWLOWSKI & WALAS, 1948); - Chyvchynsky ridge, mount Hnitesa (PAWLOWSKI & WALAS 1948); - Chyvchynsky ridge, mount Furatek (PAWLOWSKI & WALAS 1948); - Chyvchynsky ridge, mount Ladeskul (PAWLOWSKI & WALAS 1948); - Chyvchynsky ridge, mount Stoh (PAWLOWSKI & WALAS 1948); - Chyvchynsky ridge, mount Stewiora (PAWLOWSKI & WALAS 1948); - Chyvchynsky ridge, mount Luston (PAWLOWSKI & WALAS 1948);

Rozhnjativ District: - Osmoloda v. - 27.04.1941, HRYN (KW);

Kolomyja District: - Kolomyja (HERBICH 1860) - 2.05.1941 (LWS); - Separivtsi v. - 5.04.1947 (LWS); - Verbizh v. - 1940 (LWS); - Pechenizhyn v. (FOMIN & BORDZILOVSKYJ 1950); - Nyzhnje v. (SLENDZINSKI 1875);

Tlumach District: - Tlumach - 1930, LÁSKA (KRAM);

Chernivtsi Region:

Chernivtsi District: - Chernivtsi (HAYEK 1916; JAKIMCHUK 1978); - 2.04.1961, REVENKO (CHER); - 10.04.1976, PAVLJUK (CHER);

Storozhynets District: - Kryva v. - 18.04.1962, BARYKINA (CHER); - Hlybochok v. - 14.04.1978, JAKIMCHUK (CHER); Storozhynets (JAKIMCHUK 1978) - 14.04.1978, SOLODKOVA (CHER);

Hlybotsky District: - Valja-Kuzjmyno v. - 31.03.1960, HOROCHOVA (CHER); 10.04.1978, ZAJETS (CHER); 15.04.1982, KANOFINSKA (CHER);

Vyzhnytsky District: - Shepit v. - 44.04.1957, BEREZOVSKA (CHER); - Surdyn - 6.05.1961, SOLODKOVA (CHER);

Sadhirsky District: - Chernivka v. - 3.03.1960 (CHER);

Kitsman District: - Kitsman v. (HERBICH 1859; KNAPP 1872) - GUSTAWICZ (CHER).

As we can see, the species is distributed in all the floristic areas of the East Carpathians. The boundary of the continuous area passes nearly along the line of the Volcanic foothills of the Carpathians (west macroslope) and the Dniestr river (east macroslope). Patches of sites occur in the Transcarpathian lowland, in Male Polissja and Podillja.

Ecophytocenology

C. heuffelianus is distributed in all the geographical landscape zones of the region: from the lowland to alpine belt, at altitudes from 126 to 2000 m above sea level.

C. heuffelianus is a mesophyte, enduring moderate humidification, showing both mesothermophilous and psychrophilic features. Shoots of saffron individuals can often be seen through the snow which has not melted yet in highlands. It is an eutrophic species settling on rocks of various types, the edaphic factor is not the limiting

one, and it prefers mellow soils. *C. heuffelianus* is a photophilous plant, it settles preferably on open vasts but it can also grow in broad-leaved forests (beech and oak woods), enduring the shading during the phase of fruit ripening. In the works on categorization of the ecological factors for the flora of Middle Europe (LANDOLT 1977; ELLENBERG et al. 1991) there are no data on *C. heuffelianus*. According to the ecological scales of the above mentioned researchers we have estimated the relation of the species studied to the most important ecological factors: L4, T2, K4, F3, R3 (according to LANDOLT 1977) and L7, T3, K6, F5, R5 (according to ELLENBERG et al. 1991).

C. heuffelianus has a wide ecological-phytocenotic amplitude, which is also shown in its power to grow both in meadow and forest cenoses.

At the eastern area boundary in Male Polissja the species grows in *Fagetum podolicum* communities (KLEOPOV 1990), as well as in oak-hornbeam (*Querceto-Carpineta*) forests (MELNIK 1993).

C. heuffelianus according to our early report (KRICSFALUSY & MIHALY 1993, MIHALY 1993) and last investigations occurs in the following communities:

Juncetea trifidi HADAČ in KLIKA et HADAČ 44
  Caricetalia curvulae BR.-BL. in BR.-BL. et JENNY 26
    Juncion trifidi PAWL. 28
      Cetrario - Festucetum supinae JENIK 61
      Cetrario - Juncetum trifidi MALINOVSKY in MALINOVSKY et al. 91
Calamagrostio villosae-Festucetum picturatae KRAJINA 33
    Nardo-Caricion rigidae NORDHAGEN 37
      Nardetum alpigenum BR.-BL. 49

Elyno-Seslerietea BR.-BL 48
  Seslerietalia caeruleae BR.-BL in BR.-BL et JENNY 26
    Festuco saxatilis-Seslerion bielzii (PAWL. et WAL. 49) COLDEA 84
      Caricetum sempervirentis sensu DOMIN 33

Mulgedio-Aconitetea HADA et KLIKA in KLIKA et HADAČ 44
  Adenostyletalia BR.-BL. 30
    Adenostylion BR.-BL. 26
      Pulmonario-Alnetum viridis PAWL. et WAL. 49
  Calamagrostietalia villosae PAWL. et WAL. 49
    Calamagrostion villosae PAWL. et WAL. 49
      Hyperici alpigeni - Calamagrostietum villosae PAWL. et WAL. 49
      Poo - Deschampsietum PAWL. et WAL. 49

Molinio-Arrhenatheretea TÜXEN 37
  Arrhenatheretalia TÜXEN 31
    Cynosurion TÜXEN 47
      Anthoxantho-Agrostietum SILLINGER 33
      Deschampsion caespitosae (HORVATIC 30) SOÓ 71
      Deschampsietum caespitosae HORVATIC 30

Nardo-Callunetea PREISING 49
  Nardetalia OBERDORFER ex PREISING 49
    Nardion BR.-BL. 26
      Soldanello - Nardetum KRICSFALUSY et al. 91
      Festucetum rubrae sensu PUSCARU et al. 56

Festuco-Brometea BR.-BL. et TÜXEN ex BR.-BL. 49
  Festucetalia valesiacae BR.-BL. et TÜXEN ex BR.-BL. 49
    Festucion valesiacae KLIKA 31
      Medicagini - Festucetum valesiacae WAGNER 40

Alnetea glutinosae BR.-BL. et TÜXEN ex WESTHOFF et al. 46
  Alnetalia glutinosae TÜXEN 37
    Alnion glutinosae MALCUIT 29
      Carici elongatae-Alnetum KOCH 26

Querco-Fagetea BR.-BL. et VLIEGER in VLIEGER 37
  Fagetalia sylvaticae PAWŁOWSKI in PAWŁOWSKI, SOKOŁOWSKI et WALLISCH 28
    Alnion incanae PAWŁOWSKI in PAWŁOWSKI, SOKOŁOWSKI et WALLISCH 28
      Fraxino pannonicae-Ulmetum SOÓ in ASZÓD 36 corr. SOÓ 63
    Carpinion ISSLER 31
      Melampyro nemorosi-Carpinetum PASSARGE 57
      Carici pilosae-Carpinetum NEUHÄUSL et NEUHÄUSLOVÁ 64
      Stellario-Carpinetum OBERDORFER 57
    Tilio-Acerion KLIKA 55
      Tilio-Fraxinetum ZÓLYOMI 36
    Fagion LUQUET 26
      Melitti-Fagetum SOÓ 62
      Carpino-Fagetum PAUCĂ 41

Quercetea robori-petraeae BR.-BL. et TÜXEN 31
  Quercetalia robori-petraeae TÜXEN 31
    Genisto germanicae-Quercion NEUHÄUSL et NEUHÄUSLOVÁ-NOVOTNÁ 67
      Luzulo albidae-Quercetum HILITZER 32
      Pino-Quercetum KOZLOWSKA 25

Loiseleurio-Vaccinetea EGGLER 52
  Rhododendro-Vaccinietalia BR.-BL. in BR.-BL. et JENNY 26
    Rhododendro-Vaccinion BR.-BL. ex G. et BR.-BL. 31
    Rhododendretum myrtifolii PUSCARU et al. 56
    Vaccinietum myrtilli PAWŁ. et WAL. 49
  Juniperion nanae BR.-BL. et al. 39
      Juniperetum nanae BR.-BL. et SISS. 39

Vaccinio-Piceetea BR.-BL. in BRAUN-BLANQUET, SISSINGH et VLIEGER 39
  Piceetalia excelsae PAWŁOWSKI in PAWŁOWSKI, SOKOŁOWSKI et WALLISCH 28
    Pinion mughi PAWŁOWSKI in PAWŁOWSKI, SOKOŁOWSKI et WALLISCH 28
      Vaccinio myrtilli - Pinetum mugo SILL. 33

C. heuffelianus is a seasonal dominant of early-spring grass cover synusia with 2 to 5% projective cover. The analysis of works on floristic vegetation classification in Europe (PAWŁOWSKI & WALAS 1948; SOÓ 1973; MATUSZKIEWICZ 1981; MORAVEC et al. 1983; ROTHMALER 1988; DOSTÁL 1989) showed that *C. heuffelianus* is neither a typical nor a differential species in the above mentioned syntaxa. Meanwhile KLEOPOV (1990) notes *C. heuffelianus* as a species characteristic of *Fagetum podolicum* association. According to the cenotypes analysis carried out by MALINOVSKYJ 1980) *C. heuffelianus* belongs to subedificators of the main synusia.

Here we give brief characteristics of plant communities in the sites of the studied populations.

Population I grows in *Carpino-Fagetum* PAUCĂ 41 association; arborescent stratum: *Fagus sylvatica*, *Carpinus betulus*, closing of leaf canopy - 0.4 - 0.5; herbaceous stratum: *Galium odoratum*, *Glechoma hirsuta*, *G. hederacea*, *Carex sylvatica*, *Cruciata glabra* etc. The association includes 25 species altogether. The population is attached to brown podzol soils.

Population II is attached to *Stellario-Carpinetum* OBERDORFER 57 association; arborescent stratum: *Carpinus betulus, Acer campestre, A. platanoides, Tilia cordata*, closing of leaf canopy - 0.5-0.6; undergrowth: *Sambucus nigra, Rubus caesius*; herbaceous stratum: *Stellaria holostea, Anemonoides nemorosa, Glechoma hirsuta, Poa nemoralis* etc. The association includes 20 species. The population grows on brown mountain forest soils.

Population III is located in *Deschampsietum caespitosae* HORVATIC 30 association; herbaceous stratum: *Deschampsia caespitosa*, *Festuca heterophylla*, *Anthoxanthum odoratum*, *Potentilla erecta*, *Poa pratensis*, *Luzula luzuloides* etc. There are 17 species in the association. The population occurs on brown mountain forest soils.

Population IV grows in *Soldanello - Nardetum* KRICSFALUSY et al. 91 association; low shrubs: *Vaccinium myrtillus*, *V. vitis-idaea*; herbaceous stratum: *Nardus stricta*, *Potentilla erecta*, *P. aurea*, *Anthoxanthum odoratum*, *Hypericum montanum*, *Festuca rubra*, *F. gigantea*, *Trifolium repens* etc. There are 35 species in the association. The population is attached to brown mountain forest soils.

Population V is located in *Soldanello - Nardetum* KRICSFALUSY et al. 91 association; patches of *Duschekia viridis*, single samples of *Picea abies*, *Juniperus communis*, *J. sibirica;* low shrubs: *Vaccinium myrtillus;* herbaceous stratum: *Nardus stricta*, *Deschampsia caespitosa*, *Anemonoides nemorosa*, *Phleum alpinum*, *Gentiana*

asclepiadea, Anthoxanthum odoratum, Homogyne alpina etc. The association consists of 22 species. The population grows on brown mountain forest soils.

Population VI is attached to *Soldanello - Nardetum* KRICSFALUSY et al. 91 association; single samples of *Juniperus communis*; low shrubs: *Rhododendron myrtifolium*, *Vaccinium myrtillus*, *V.vitis-idaea*, *V. uliginosum*; herbaceous stratum: *Nardus stricta*, *Cardaminopsis ovirensis*, *Poa chaixii*, *Pulsatilla alba*, *Parageum montanum* etc. The association includes 19 species. The population occurs on brown mountain forest soils.

Population VII grows in *Anthoxantho-Agrostietum* SILLINGER 33 association; herbaceous stratum: *Anthoxanthum odoratum*, *Agrostis tenuis*, *Arrhenatherum elatius*, *Ranunculus acris*, *Briza media*, *Dactylis glomerata*, *Campanula patula* etc. There are 35 species in the association. The population grows on brown mountain forest soils.

Population VIII is located in *Carici elongatae-Alnetum* KOCH 26 association; arborescent stratum: *Alnus glutinosa, Betula pubescens, Fraxinus excelsior*, closing of leaf canopy - 0.5-0.6; undergrowth: *Corylus avellana, Rubus idaeus, Frangula alnus*; herbaceous stratum: *Carex elongata, Filipendula ulmaria, Aegopodium podagraria, Calamagrostis canescens, Iris pseudacorus, Oxalis acetosella* etc. There are 19 species in the association. The population is attached to sod-podzolic soils.

Populations IX and X grow in *Pino-Quercetum* KOZLOWSKA 25 association; arborescent stratum: *Pinus sylvestris, Quercus robur, Betula pendula, Populus tremula, Carpinus betulus*, closing of leaf canopy - 0.6-0.7; herbaceous stratum: *Carex brizoides*, *Galium odoratum, Aegopodium podagraria, Maianthemum bifolium, Oxalis acetosella* etc. There are 20 and 23 species in the associations accordingly. The populations occur on sod-podzolic soils.

Phenology

Observations of the seasonal rhythm of *C. heuffelianus* development showed that it varies with the altitude of the population sites above sea level (Fig. 4). For example, in the highland the vegetation begins about 1.5 month (40-50 days) later than in the lowland. The above-ground part develops and exists about 3 months. The new root system forms in autumn, it endures winter frosts, and further functions in spring, dying out after fruitage and seeding. The phenorhythmotype of *C. heuffelianus* development is that of early spring flowering with the summer-winter rest period.

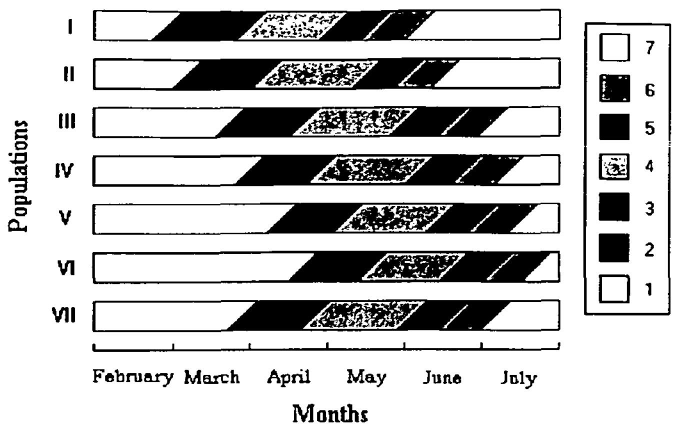


Fig. 4: Phenological spectra of *C. heuiffelianus*: 1,7 - rest; 2 - budding; 3 - flowering; 4 - fruitage; 5 - dissemination; 6 - dying out of above ground parts

Biomorphology

Morphological structure data of *C. heuffelianus* are reported by many researchers (IRMISCH 1850; GÖEBEL 1882; MAW 1882, in: SHORINA 1975; BUXBAUM 1934; TROLL 1937; ARTJUSHENKO 1970). Their attention was directed mainly to the bulbotuber structure. The vegetative part of the plant consists of the bulbotuber, peduncle and leaves. At the bulbotuber base there are the roots. Vegetative reproduction occurs annually; the old bulbotuber is replaced by a new one, developing in its upper part.

The bulbotuber of *C. heuffelianus* is an annual underground organ, forming during one vegetation period. It persists until the next vegetation period, then the food supply is completely spent for flowering, fruitage and seed formation. It is replaced by the new bulbotuber accumulating the nutrients formed by the leaves after the flowering in the same vegetation period. For the pregenerative individuals the monopodial branching is typical, becoming sympodial at the generative phase. So mono-sympodial branching type is characteristic of *C. heuffelianus*.

Morphogenesis: The reproduction bud is formed in the middle of summer when the plant is in the state of rest. It grows very slowly and its growth processes only increase next spring. After the maternal plant has shed its blossom it proceeds to form a flower in the vegetative cone, and the flower starts to bloom nextear. At the same time fruits and seeds are setting on the maternal plant, then the whole aboveground portion and roots wither. The plant enters the period of summer rest. During the autumn rooting of the newly formed bulbotuber the vegetation cone continues to

develop and the apical internodes grow. Further processes are hindered with coming winter frosts. The plant enters the winter rest period. Germination of the reproduction bud formed 2 years ago starts just after the spring snow melting. Together with the leaves the flower buds appear above the soil surface, which start blooming very soon. The life cycle of the regeneration bud and that of the plant having grown from it are completed in late spring - early summer by fruit and seed formation. Thus, it takes 2 years from the moment of the reproduction bud formation until the fruitage of the plant grown out of it. Of this time, for about 21 months the sprout exists as a reproduction bud on the underground organ, and for about 3 months as a vegetating and fruiting plant.

Ontogenesis: Classification of *C. heuffelianus* individuals by age stage was carried out using of all qualitative and quantitative biomorphological features. In the plant ontogenesis we have differentiated (MIHALY 1993) three periods and five age stages (Fig. 5, Table 1). Separate data on *C. heuffelianus* ontogenesis were given in the studies by KOMENDAR & NEIMET (1980), DROGOBETSKAJA (1984) and MELNIK (1993).

I. Latent stage: Seeds in the state of rest (sm): The ripe seeds are rounded, ellipsoid, covered with a reddish-brown coat, with a small aril. The seed length is 3 to 4 mm, the seed width is 2 to 2.5 mm, 1000 seeds weigh 4.77 to 7.45 g.

II. Pregenerative stage: Sprouts (p): They appear in autumn. The type of germination is underground. The cotyledon consists of a sheath, connective and haustorium. In spring a small bulbotuber forms, along with a green assimilating leaf, at first having a thread-like form, which helps to work its way through the leaf litter. At the same time the transition into the juvenile state takes place.

Juvenile individuals (j): Each has an assimilating leaf, the bulbotuber is vertically elongated, somewhat larger than that of the radicles. The number of bottom leaves depends on the age of the juvenile individual: with every coming year it has one bottom leaf more. It stays in the juvenile stage for 3 to 4 years.

Immature individuals (im): One assimilating leaf, 4 bottom leaves. The bulbotuber is larger and less elongated vertically than it is in the juvenile plants (acquires a more flattened form). There is a contractile root, by which the bulbotuber deepens into the soil. Deepening of the bulbotuber into the soil by means of the contractile root goes on. The number of roots increases. The green leaf is wider than that of the juvenile individuals.

Virgin plants (v): Mature individual in the vegetative stage. They have 2 to 3 leaves. The size and form of the leaves and of the bulbotuber are the same as those of the generative individuals. Contractile roots occur very rarely. The virginal stage lasts usually one year.

III. Generative stage: Generative plants (g): This age stage comes by the 5th-6th year of the plant life. They have 2 to 3, very rarely 4 assimilating leaves, a large bulbotuber with a great number of roots. There is one flower, it is large. The roots grow in all directions: downward, horizontally and upward. Contractile roots have not been found. The generative stage is the longest one within the ontogenesis.

Analyzing the plant ontogenesis at the eastern area boundary, MELNIK (1993) does not differentiate immature individuals as a separate age stage. In the vegetative and generative plants 2 to 4 assimilating leaves are noted. Not a single of the studied populations had any vegetative individuals with 4 leaves. In the generative individuals these occur very rarely, as an exclusion.

In the course of ontomorphogenesis such phases replace each other: primary sprout (p-v), principal sympodium (g-s). The general length of ontomorphogenesis is not less than 15 years.

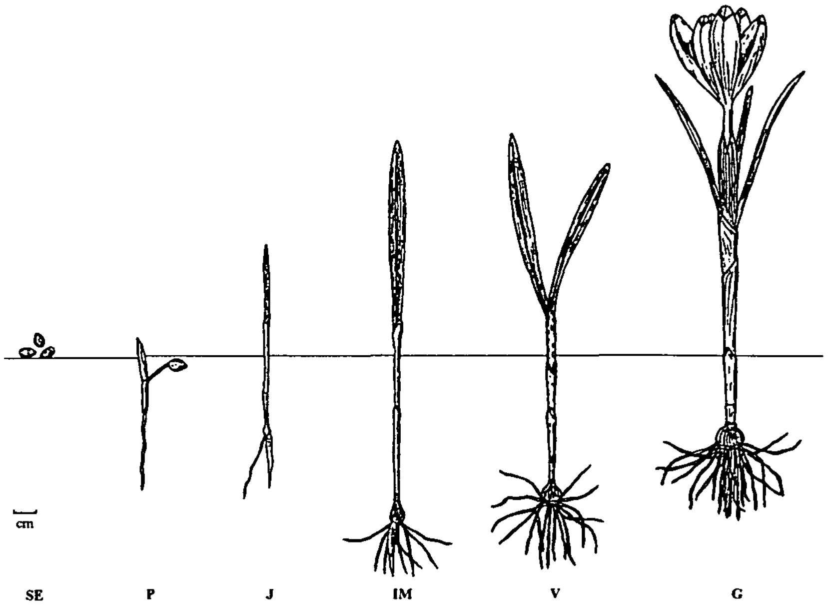


Fig. 5: Ontogenesis of *C. heuffelianus*: se-g - indices of age states: se - seeds; p - sprouts; j - juvenile; im - immature; v - virginal; g - generative individuals.

Age group	Bulbotuber			Number of roots, pcs	Mass of bulbotuber/ Number of roots	Depth of bedding, mm
	height, mm	diameter, mm	mass, g			
j	1.93±0.40	2.33±0.46	0.009±0.002	3.13±0.32	0.003	33.80±2.34
im	6.80±0.49	6.20±0.37	0.102±0.02	13.60±1.72	0.008	73.00±2.02
v	8.20±0.53	7.90±0.35	0.198±0.03	22.90±2.14	0.009	64.70±2.83
g	9.68±0.29	11.96±0.36	0.59±0.05	43.20±3.14	0.014	42.00±6.32

Age group	Assimilating leaf			Height of peduncle, mm	General height, mm
	number, pcs	length, mm	width, mm		
j	1.0	80.00±4.02	2.87±0.21	-	-
im	1.0	162.00±3.24	5.90±0.40	-	-
v	2.200.±13	149.40±6.49	5.67±0.33	-	-
g	2.24±0.10	165.86±5.41	7.11±0.31	38.32±2.30	195.32±5.40

Table 1: Biomorphological characteristics of *C. heuffelianus* individuals of different age groups

For *C. heuffelianus* 2 reproduction cycles are characteristic: a long one - by seeds and a short one - by vegetative germinants, or cloves, not deerly rejuvenated. The long cycle embraces the stages from p to g, the short one - from v to g. The short reproduction cycle occurs in *Crocus* populations very rarely.

C. heuffelianus can be qualified as a biomorph of the monocentric type with an early non-specialized disintegration. According to the classification of ARTJUSHENKO (1970), it belongs to the herbaceous polycarpics with the underground organs of the stem origin and the regeneration bud on the top of the bulbotuber.

Karyology

The chromosome number for *C. heuffelianus* 2n=14 was first calculated by MATHER (1932). The same data were given in the works by KARASAWA (1943, 1950, 1951). Later, in their thorough caryological processing of the genus *Crocus*, BRIGHTON et al. (1973) noted for *C. heuffelianus* studied from 8 localities in Yugoslavia and one in Czechoslovakia, the following chromosome numbers: 2n=12, 18, 20, 22, 23. Later on BRIGHTON (1976) noted 2n=10 for localities in Ukraine and Roumania.

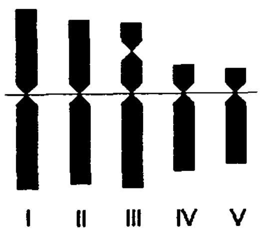


Fig. 6: Karyogram of the *C. heuffelianus* haploid set.

We have already noted earlier that *C. heuffelianus* is included into the taxonomic complex of *C. vernus* agg., which unites *C. vernus* subsp. *albiflorus* (*C. albiflorus*) with 2n=8 (SKALINSKA 1966, 1968) and *C. vernus* subsp. *vernus*, which includes *C. heuffelianus* with varying chromosome numbers, given above. However, *C. heuffelianus* in its turn is also a taxonomic complex distincly subdivided into separate species, e.g. *C. scepusiensis* (REHM. et WO L.) BORB. with 2n=18 (MURIN & HINDAKOVA 1984; MAJOVSKY et al. 1990).

In the Carpathian region the chromosome number for *C. heuffelianus* is noted to be 2n=10 (BRIGHTON 1976; MURIN & HINDAKOVA 1984; MAJOVSKY et al. 1990) and for *C. scepusiensis* it is 2n=18. In the area of the East Carpathians the chromosome number 2n =10 has been stated (KISH 1995), population I and II and two separate localities more having been studied caryologically. *C. heuffelianus* caryotype has been stated to consist of 3 pairs of large metacentric chromosomes (chromosomes with the median centromere according to LEVAN et al. (1964)), one of which contains a secondary constriction and two pairs of the small subacrocentric chromosomes as WHITE (1945) treats them, or of the chromosomes with the subterminal centromere according to the classification of LEVAN et al. (Fig. 6). It is interesting to note that according to the data given by BRIGHTON (1976) the plants in the populations of Roumania (2n=10) have chromosomes without the secondary constriction; however, the same author notes them in the plants of Ukraine (Khust, Transcarpathian region). Secondary constrictions in the plant caryotypes with 2n=10 have been also noted in populations of Slovakia (MURIN & HINDAKOVA 1984; MAJOVSKY et al. 1990).

Reproductive Biology

V e g e t a t i v e   r e p r o d u c t i o n: Vegetative reproduction of *C. heuffelianus* begins in forming of one, rarely two vegetative buds in the axils of the scales, which then turn into mature bulbotubers. The vegetative bud is formed on the young bulbotuber of the current year, and in the next year it forms a lateral shot - a clove, which is the vegetative reproduction organ. In the third year, while the maternal bulbotuber is dying away the young shoot separates completely and becomes an independent plant.

In natural conditions *C. heuffelianus* has been stated to have three types of vegetative reproduction. The first type, in the generative stage, is followed by formation of generative or virginal vegetative progeny. This is a normal particulation with not deep rejuvenation of the progeny. The second type, senile particulation, has been stated in the period when the senile plant is dying, forming a juvenile individual. Young pe-

riod particulation is accompanied by forming of the progeny of immature and juvenile age stages on the virginal and immature individuals accordingly. Of all the vegetative reproduction types, normal particulation occurs most often. In general, potential productivity of the vegetative germinants in *C. heuffelianus* is low, which is caused by annual vegetative reproduction of the maternal bulbotuber.

Anthecology: The flowers of *C. heuffelianus* are single, erect, perfect, actinomorphic. The perianth consists of a long tube and a bend, formed by six segments, placed in two circles. The ovary is inferior, it is underground. There are nectaries formed by the septal glands, at the base of the bend. On the upper edges of the segments of the external and internal perianth circles there is a V-like dark violet spot. There are 3 stamens, in the base growing together with the upper part of the perianth tube. The anthers are upright, oblong, they open to form longitudinal slits turned to the gynoecium. The style is thread-like, long, often reaches more than 10 cm, the pistil is 3-lobed, it is either higher than the stamens or on the same level. *C. heuffelianus* is an entomophilous species with a well-developed system of primary (pollen, nectar) and secondary (smell, visual lure) attractants. The main organ for attracting insects is the perianth. It is of a great size, bright violet colour, it has a strong scent. The yellow colour of the pistil and stamens also attract insects. In spite of the unfavourable ecological conditions for insect pollination in the highland, it does occur (population VI). It can be explained by the increase of the flower size in relation to the other plant parts.

Flowering and pollination of *C. heuffelianus* take place in March - early April in the lowland and in June - early July in the highland. Depending on the weather conditions of the season, flowering can begin earlier or later. The anthers crack on the second-third flowering day and pour out a great amount of pollen sticking together in small lumps. One flower blooms 5 to 8 days. The flowers close for night. When it is raining or the sky is overcast the flowers do not open (adaptation for defence of the pollen against getting wet).

According to our data, the main pollinators of *C. heuffelianus* are *Apis mellifera* L. and *Bombus terrestris* L. *Meligethes aeneus* F. is found on the flowers as well. In some researchers' opinion, certain species of *Lepidoptera* can also be the pollinators (KIRCHNER 1911). Protandry is typical for *C. heuffelianus* - the anthers ripen earlier than the pistil. This is a defensive mechanism, preventing self-pollination. The position of the pistil above the stamens can be considered as the same mechanism.

Seed reproduction: Observations of the seasonal rhythm of *C. heuffelianus* fruitage have shown that seeding of the populations in the lowland takes place in early May, and in the highland conditions - in late June. The ripe seeds pour out of the opened capsules. Sometimes the capsules do not crack completely, and then in their lower parts some seeds remain. *C. heuffelianus* is an autochore, since its dissemination is effected by the passive shedding of seeds. We have also registered dissemination made by ants.

Generative reproduction: The results of the *C. heuffelianus* seed productivity studies are given in Table 2. As a whole in all the populations the variation of the seed amount (V: 22.22-54.01%) is higher, than that of the seed germinants (V: 12.25-30.79%). In the highland populations all the elements of seed productivity vary to greater.extend. Cases of the lowest number of both seed germinants and seeds in capsules have been registered there; their highest number has been noted in population III. Thus, the environmental conditions in the highland do not favour the seed germinants formation and their turning into fully developed seeds. Dissemination in all the studied populations reaches a high level (DP = 53.36-76.09%), the highest index being noted in foothill population II. Variation of seed reproduction elements of the populations depending on their altitude above sea level is not clinal. Almost similar values of PSP, RSP and DP in the populations of southern and northern macroslopes of the East Carpathians, located in the lower mountain belt (III and VII) with certain predominance of the indices of the first group of the populations should be noted. To investigate the interdependence between the number of seed germinants and seeds, a correlation analysis has been carried out. The calculated correlation coefficients show the actual dependence between the studied parameters. The independence between the number of seed germinants and seeds along with the high DP values prove good adaptation of the species to the present day conditions of life.

The seed productivity of *C. heuffelianus* has been repeatedly studied in certain areas of the East Carpathians (VAINAGIJ 1962; KOMENDAR & NEIMET 1980; DROGOBETSKAYA 1984; KOMENDAR & KRICSFALUSY 1986; KRICSFALUSY et al. 1988; MALYNOVSKYJ 1991; VAINAGIJ & VAINAGIJ 1993) and of Kamjanetske Prydnistrovja (KOVALCHUK et al., 1993). According to the studies carried out by VAINAGIJ (1962) at different altitude belts of the northern macroslope, PSP of *C. heuffelianus* varies from 23.36 to 26.05, RSP - from 11.65 to 15.45, DP - from 48.04 to 66.14%. Below we give the results of seed productivity studies of *C. heuffelianus* in the conditions of the southern macroslope: beech forests of the mountain zone - PSP - from 28.0 to 30.2, RSP - from 24.0 to 26.8, DP - from 85.7 to 91.8%; lower mountain belt - PSP - 27.60, RSP - 21.86, DP - 79.20%. According to the observations made by DROGOBETSKAYA (1984) DP for the highland population of *C. heuffelianus* amounts 77.4%, for the lowland population it is 80%. MALYNOVSKYJ (1991) notes that RSP increases with the altitude, but it remains constant in certain years, while PSP varies greatly. Our observations show the similar degree of annual variation of RSP and PSP. The yield of seeds per area unit in population VII reaches the values of an order higher than in the rest of the populations, which is caused by the high density of individuals in this site. In addition, the seed yield indices in populations II and V are also high. The plant reproduction at the population level has been estimated through the index of recovery (Table 3), its amplitude of values within the studied species being found rather great (105.6-1361.4%). The populations of Male Polissja, whose recovery index is essentially lower than that of the Carpathian ones, are distinctly

isolated. Among the populations of the Carpathians the high level of reproduction is typical for populations II and VII, in the former it is caused by ecologophytocenotic optimum realization, in the latter - by a very great number of the juvenile individuals. Comparatively low value of the recovery index of population V is the consequence of the presence of a great number of generative individuals in it.

Comparing the values of *C. heuffelianus* seed reproduction elements in different geographical regions, we can arrive to the conclusion that their parameters are higher in the essentially lower populations of the southern macroslope of the East Carpathians. In the northern macroslope they are (even such a relatively stable index asPSP acquires there the smallest values). The results of all our studies prove that RSP varies more than PSP. Rather high values are attained by the elements of seed reproduction of the species in Kamjanetske Prydnistrovja (PSP amounts from 23.76 to 28.20, RSP - from 18.40 to 22.81, DP - from 73.3 to 80.2%).

The analysis of *C. heuffelianus* seed reproduction shows good adaptation of the species to the site conditions at the latitudinal and altitudinal area boundaries and its high ecological plasticity.

Demography

Age structure: Analysing age spectra of *C. heuffelianus* (Fig. 7, Table 3) we can see that, first, in all the populations the share of pregenerative individuals considerably exceeds that of generative ones. Second, in all the populations senile individuals are completely absent, what can be explained by oligocarpicity caused by exhaustion of the plants after fruitage. Third, in all the populations self-regulation is realized mostly by seeds. The disparity between the great number of juvenile individuals and the small number of generative ones can be explained by high seed productivity, as well as by considerable elimination of the undergrowth at the further stages of ontogenesis. Comparatively small numbers of generative individuals forms a great number of viable seeds which in turn replenish the population with the juvenile individuals. Populations I-IV and VI -X are full-membered, young, with the left -side spectrum, of the invasion type. Populations with similar structure have been described by KOMENDAR & NEIMET (1980) in the beech forests of the Carpathian mountain zone; we also noted them earlier (KOMENDAR & KRICSFALUSY 1988) in the subalpine dense-sod grass meadows. Population V is a bimodal full-membered, normal one. Somewhat smaller percentage of juvenile individuals in the highland populations is apparently caused by the affect of unfavourable factors on the seed germination (highgrass infestation, severe climatic conditions). Apart from the above mentioned types of structure, in the beech forests near polonynas we have also found populations with the predominance of the generative individuals (KOMENDAR & KRICSFALUSY 1988).

Population	Year of studies	Potential seed productivity						Factual seed productivity						See-ding percentage	Seed yield (pcs/ m^2)
		X	Sx	*t*	*V* (%)	*P* (%)	min-max	X	Sx	*t*	*V* (%)	*P* (%)	min-max		
I	1990	30.52	1.02	29.78	16.79	3.36	22-39	17.32	1.05	16.42	30.45	6.09	10-33	56.75	381.04
	1991	31.68	1.05	30.04	16.65	3.33	23-40	18.64	1.16	16.11	31.05	6.21	9-35	58.84	410.08
	1992	29.32	1.13	25.96	19.26	3.85	17-40	15.84	1.03	15.44	32.38	6.48	9-26	54.03	348.48
II	1990	30.24	0.93	32.65	15.31	3.06	21-39	21.04	1.19	17.75	28.17	5.63	7-33	69.58	925.76
	1991	29.88	1.05	28.56	17.51	3.50	21-39	20.20	1.37	14.77	33.85	6.77	9-35	67.60	888.80
	1992	31.12	0.76	40.83	12.25	2.45	24-38	23.68	1.14	20.72	24.13	4.83	11-32	76.09	1041.92
III	1990	24.72	0.77	32.14	15.56	3.11	18-35	13.72	0.93	14.81	33.76	6.75	5-24	55.50	480.20
	1991	26.00	1.60	16.24	30.79	6.16	12-50	19.20	1.39	13.84	36.12	7.22	9-44	73.85	672.00
	1992	30.60	1.29	23.63	21.16	4.23	19-42	20.32	0.90	22.50	22.22	4.44	14-32	66.41	711.20
IV	1990	29.96	0.82	36.74	13.61	2.72	23-40	19.08	1.10	17.35	28.82	5.76	9-32	63.68	381.60
	1991	31.24	1.20	25.94	19.28	3.86	21-42	21.04	1.81	11.65	42.92	8.58	6-38	67.35	420.80
	1992	30.32	0.84	36.09	13.85	2.77	23-41	18.36	1.11	16.54	30.24	6.05	8-31	60.55	376.20
V	1990	22.56	1.04	21.67	23.07	4.61	11-31	13.24	1.33	9.94	50.30	10.06	1-25	58.69	794.40
	1991	22.32	1.03	21.39	23.38	4.68	16-35	14.72	1.59	9.26	54.01	10.80	3-30	65.95	883.20
	1992	26.08	1.39	18.74	26.68	5.33	11-38	17.24	1.36	12.64	39.56	7.91	6-28	66.10	1034.40
VI	1990	23.96	0.90	26.49	18.88	3.78	13-34	16.00	1.44	11.09	45.07	9.01	5-29	66.78	704.00
	1991	22.35	1.28	17.42	27.54	5.74	9-34	13.17	1.38	9.57	50.13	10.45	3-23	58.93	579.48
	1992	20.44	0.99	20.72	24.14	4.83	8-28	14.84	0.95	15.57	32.12	6.42	2-24	72.60	652.96
VII	1990	25.64	1.13	22.70	22.03	4.41	17-40	16.48	1.48	11.17	44.77	8.95	6-32	64.27	1911.68
	1991	28.60	1.04	27.44	18.22	3.64	21-40	20.12	1.15	17.57	28.45	5.69	10-35	70.35	2333.92
	1992	27.96	1.08	25.83	19.36	3.86	19-41	14.92	0.78	19.06	26.24	5.25	8-23	53.36	1730.72

Table 2: Seed productivity parameters of different populations of *C. heuffelianus* in East Carpathians

Population	Number of individuals, pcs/m²	Age group						Recovery index, %
		j	im	v	g	j+im	v+g	
I	360	217/60.28	51/14.17	70/19.44	22/6.11	268/74.44	92/25.56	986.36
II	882	599/67.91	107/12.13	132/14.97	44/4.99	706/80.04	176/19.96	1361.36
III	647	376/58.11	92/14.22	144/22.26	35/5.41	468/72.33	179/27.67	1074.29
IV	316	160/50.63	64/20.25	72/22.28	20/6.33	224/70.89	92/29.11	800.00
V	332	160/48.19	60/18.07	52/15.66	60/18.07	220/66.27	112/33.73	266.67
VI	532	272/51.13	36/6.77	180/33.84	44/8.27	308/57.89	224/42.11	618.18
VII	2105	1578/74.96	132/6.27	279/13.25	116/5.51	1710/81.24	395/18.76	1360.34
VIII	64	12/18.75	21/32.81	28/43.75	3/4.69	33/51.56	31/48.44	400.00
IX	166	38/22.89	54/32.53	52/31.33	22/13.25	92/55.42	74/44.58	172.73
X	108	19/17.59	15/13.89	56/51.85	18/16.67	34/31.48	74/68.52	105.56

Table 3: Age structure and density of *C. heuffelianus* populations

Note: The number of individuals per m² is in the numerator; their percentage of the total number of all the age groups is in the denominator.

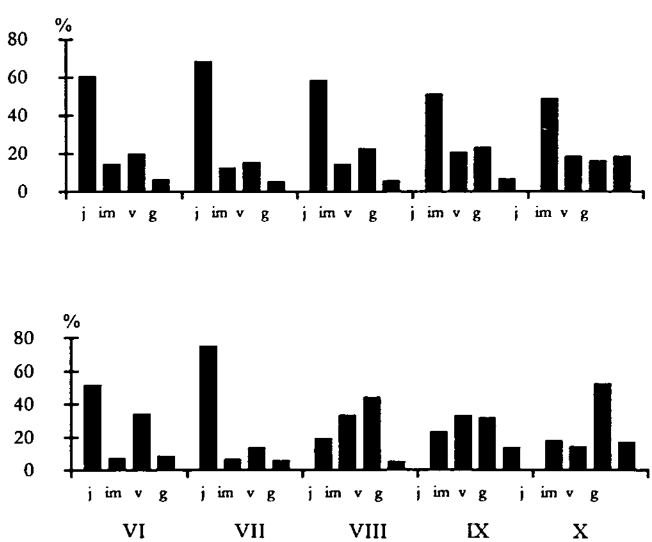


Fig. 7: Age spectra of *C. heuffelianus* populations: I-X -populations; j-g - indices of age states.

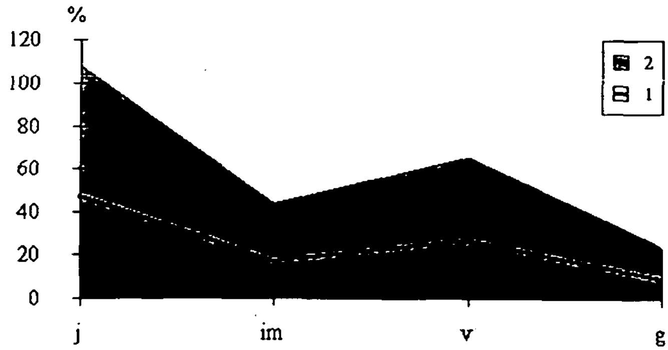
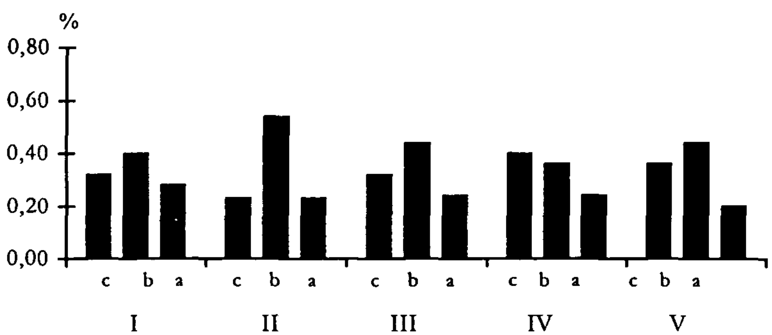


Fig. 8: Basic age spectrum of *C. heuffelianus* populations: j-g - indices of age states; 1 - basic age spectrum; 2 - zone of basic spectrum (± 3δ).



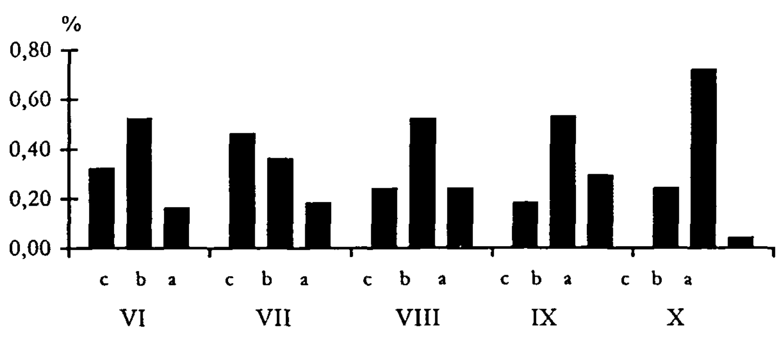


Fig. 9: Vitality spectra of *C. heuffelianus*: I-X - populations; a-c - vitality classes; on the axis of ordinates - frequencies in decimals.

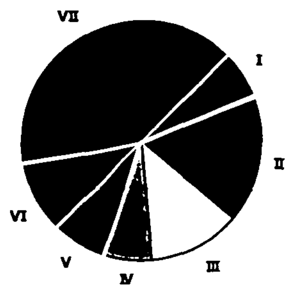


Fig 10: Density of *C. heuffelianus* populations: I-VII - populations

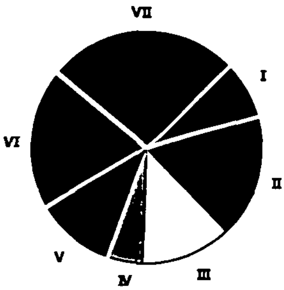


Fig. 11: Phytomasses of *C. heuffelinaus* populations: I-VII - populations.

Population	Age group				Phytomass of the population, g/m²
	j	im	v	g	
I	0.03 / 6.51	0.24 / 12.24	0.41 / 28.70	2.03 / 44.66	92.11
II	0.05 / 29.95	0.15 / 16.05	0.62 / 81.84	1.54 / 67.76	195.60
III	0.10 / 37.60	0.15 / 13.80	0.23 / 33.12	1.50 / 52.50	137.02
IV	0.03 / 4.80	0.15 / 9.60	0.24 / 17.28	1.21 / 24.20	55.88
V	0.03 / 4.80	0.18 / 10.80	0.37 / 19.24	1.38 / 82.80	117.64
VI	0.11 / 29.92	0.27 / 9.72	0.73 / 131.40	1.29 / 56.76	227.80
VII	0.05 / 78.90	0.14 / 18.48	0.20 / 55.80	1.22 / 141.52	294.70

Table 4: Phytomass of individuals and populations of *C. heuffelianus*
Note: the mass of individuals is in the numerator, g; the of age groups of individuals is in the denominator, g/m².

The analysis of the age structure of *C. heuffelianus* populations allows to unite them into a single type of the base spectrum (Fig. 8), characterized by the prevalence of the virgin individuals group. Within the spectrum we single out two variants, the first of which (Carpathian populations) is noted by the high ratio of the juvenile individuals and the second one (Pollissian populations) is characterized by the great contribution of the immature individuals. Meanwhile, somewhat isolated status of population V should be noted, characterized by the predominance of immature and generative individual groups at their almost equal proportion. The share of the juvenile individuals in the Carpathian populations is on the average about three times as high as the corresponding index of the Polessian populations which may be caused by better radication of seedlings growing nearer to the centre of the area than those

growing at its boundary. The lower density of populations VIII, IX and X also proves this.

Vitality structure: The vitality of individuals and popula tions was estimated in two key features: the phytomass of the whole plant and reproductive effort. In the vitality structure populations I-III, VIIIX are prosperous, population VI is close to equilibrium, populations IV, V, VII are depressive (Fig. 9). As can be seen, prosperous populations are forest ones of the lowland, foothills and lower mountain belt for which the ecological factors are optimal. The depressive state of population VII is caused by its high density (2105 Pcs/m^2), which in this case is a limiting factor. Highland populations are generally depressive, and in this case the limiting factor is due to the severe ecological conditions. Close to the equilibrium the state of population VI is apparently caused by the fact, that at the upper area boundary in the extraordinary conditions its strategy is directed mainly to survival which is reflected in the increase of the size of reproductive organs and their phytomass against the general plant phytomass.

Functional structure: Space structure of the whole number of the studied population is random (weakly diffuse). This is caused by the low energy of vegetative reproduction, although *C. heuffelianus* has a physiologically functional power of vegetative reproduction.

C. heuffelianus is characterized by relatively high density of the Carpathian populations, varying from 316 Pcs/ m^2 (Population IV) to 2105 PcS/m^2 (Population VII). The highest density has been found in the populations of foothills and lower forest belt, the lowest density is in the populations of the subalpine and upper forest belts (Fig. 10, Table 3). In the Pollesian populations the density indices are considerably reduced (64-166 Pcs/m^2). Obviously, as the populations are located farther from the centre and closer to the periphere, their density decreases. Certain information on *C. heuffelianus* thickets density is given by ARTJUSHENKO & KHARKEVICH (1956) and MELNIK (1993).

Relatively low phytomass of population I (in g/m^2) can be explained by the massive alienation of the generative individuals while blooming (Fig. 11). The analysis of distribution of the generative individuals' phytomass has shown that its largest share falls to the bulbotuber, while the smallest one falls to the leaves (Fig. 12).

The phytomass of generative individuals varies from 1.21 g (Population IV) to 2.03 g (Population I). The leading places in the share of the whole phytomass are taken by the group of generative individuals (Populations I, III-V, VII) and that of virginal ones (Populations II, VI) (Fig. 13). The main contribution into the whole phytomass of the populations is made by the group of mature individuals (v+g). Sometimes rather considerable share in the whole phytomass of the population can be provided by

the juvenile individuals (Populations IV and VII) (Table 4). In general the whole phytomass of the populations varies from 9.2 x 10 kg (Population I) to 11.3 x 10^4 kg (Population VI).

The estimation of the ecological and phytocenotic optima of *C. heuffelianus* and their ratio on the level of individuals and that of populations has shown that in the sites of populations I-VI the optimum of individuals is realized while in population VII that of the population is realized (Fig. 14). With the increase of altitude above sea level the vitality of the individuals in the populations gradually decreases. The level of population vitality varies depending on the concrete ecologo-cenotic conditions of the environment. The maximum index of combination of both optima can be observed in the site of population VII. This is caused by the high populational indices which are determined by specific orographic conditions (growing in the relief microdepression) and by the absence of the possibilities to increase the population area. Owing to these causes the population density attains critical values, which in turn influences negatively the vitality level of the individuals. The estimation of the parameters of the rest six populations shows that the combination of ecologophytocenotic conditions on the level of individuals and that of populations is closest to the optimum in the site of population II.

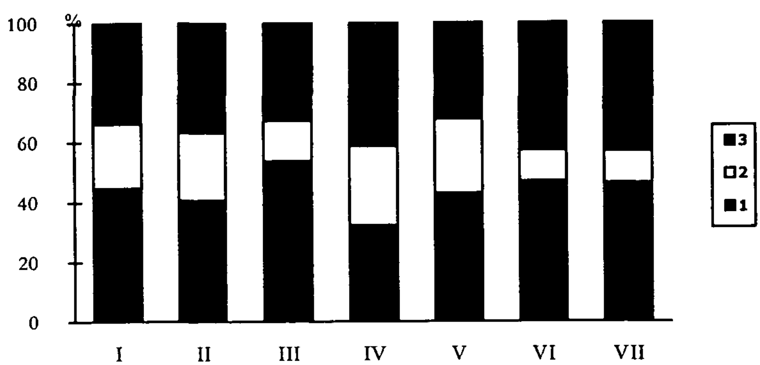
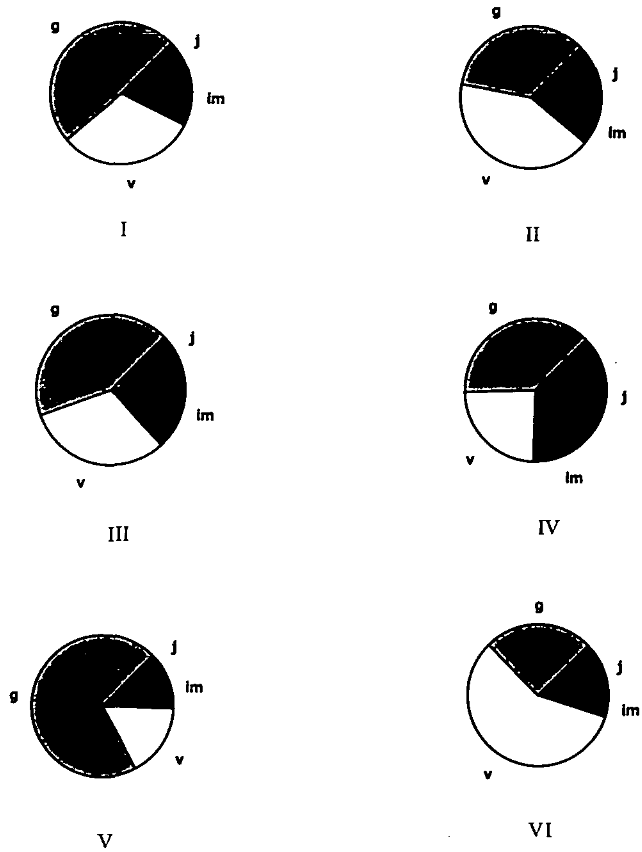


Fig. 12: Distribution of phytomass in *C. heuffelianus* individuals: 1 - phytomass of the bulbotuber; 2 - phytomass of the leaves; 3 - phytomass of the reproductive part.



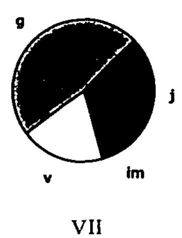


Fig. 13: Phytomasses of age groups of *C. heuffelianus* populations: I-VII - populations; j-g - indices of age states.

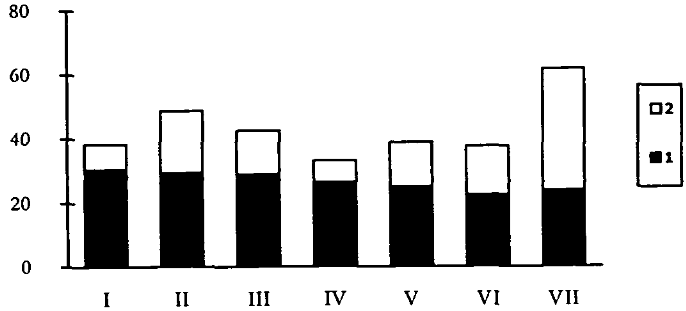


Fig. 14: Ecological phytocenotic optima of *C. heuffelianus* populations: I-VII - populations; 1 - optimum on the individual level; 2 - optimum on the populations level.

On the basis of the analysis of the most appreciable features of the species strategy in various ecological phytocenotic conditions, it should be concluded that in the integral behaviour features *C. heuffelianus* is most closely related to the false explerents (RK).

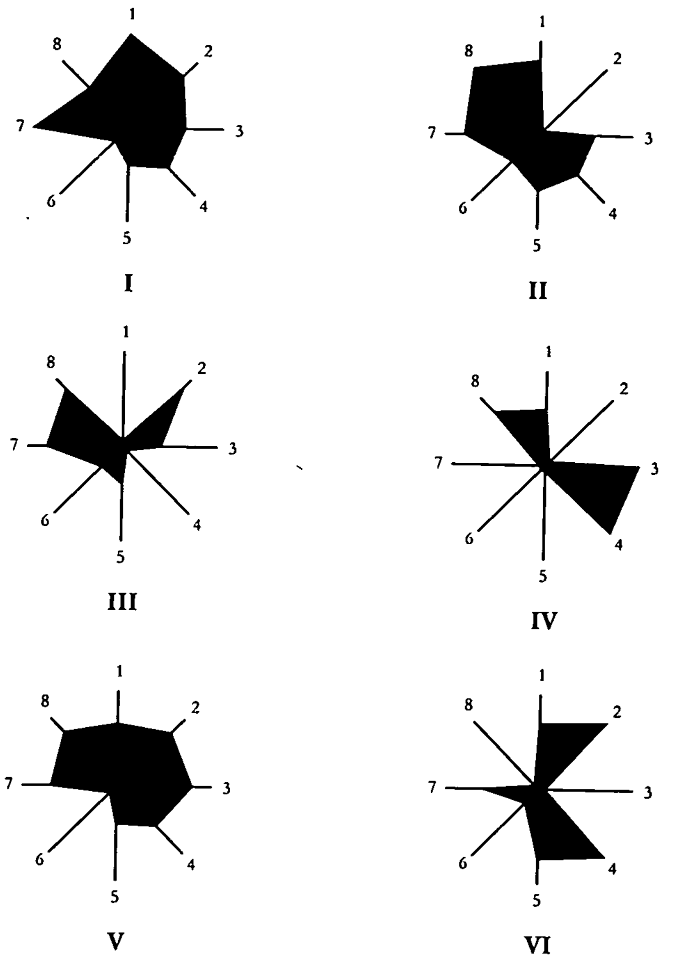
However, all the populations differ from one another in the sets of the main features which are caused by the combinations of organism and population indices in the concrete ecologo-cenotic conditions (Fig. 15).

Species conservation

The reducing area and decrease of the popultion numbers of *C. heuffelianus* are caused by anthropogenic affect. This is the reason of including it into the list of rare plants of Ukraine (CHOPIK 1978; CHOPIK et al. 1988) and the Ukrainian Red Data Book (Chervona knyha Ukrainskoi RSR, 1980). It is included also into the list of species compiled for the second edition of the Ukrainian Red Data Book (ZAVERUKHA 1992), as a disappearing plant. The main phytosoziological criterium, chorology (location of the extreme area boundaries in Ukraine) is the argument of the necessity of the species protection. CHOPIK (1978) qualifies *C. heuffelianus* as a rare species, being potentially under the danger of disappearance as a result of reducing population.

numbers and area due to the interference by man or for natural reasons. In our opinion, the status of *C. heuffelianus* as a disappearing plant, should be changed into that of a species the area of which is reducing.

High decorative qualities of *C. heuffelianus* cause constant attention of floriculturists. This plant growing on garden border and flower beds is very attractive because in early spring it forms a characteristic impressive aspect. *C. heuffelianus* is considered also as a valuable honey plant (GLUKHOV 1955; DRĂGULESCU 1983). Bees come to the flowers to take both pollen and nectar. GLUKHOV (1955) believes that the crocus



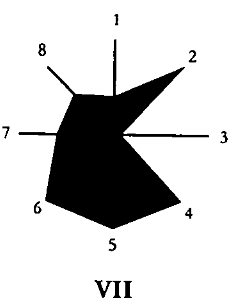


Fig. 15: Strategies of *C. heuffelianus* populations: I-VII - populations; 1-8 - indices of behaviour: 1 - ratio of the total area of the leaves to their phytomass, cm²/g; 2 - ratio of the bulbotuber phytomass to the total amount of plant phytomass, g; 3 - regio of the leaves phytomass to the total amount of plant phytomass, g; 4 - reproductive effort, g; 5 - phytomass of the population, g/m²; 6 - ecological density of the population, Pcs/0,25 m²; 7 - phytomass of the element, g; 8 - actual seed productivity, pcs/individual.

is a valuable plant for agriculture since it supplies bees with pollen and nectar when there are very few flowering plants.

Having high ecological plasticity, *C. heuffelianus* is successfully cultivated in botanical gardens (Dekorativ̌nye travyanistye rasteniya ..., 1977; Redkije i nuzhdayushchijesja v okhrane rastenija ..., 1981). However, cultivation of the plant is not sufficient for its conservation; protection of populations in all communities developing in natural conditions and forming the gene pool is necessary. The highland populations of *C. heuffelianus* are not so troublesome, inspite of the fact that the species is a component of the fodder base of *Sus scrofa* L. As the observations carried out in the West Carpathians (KAZMIERCZAKOWA & POZNANSKA 1992) have shown, the presence of these consortive relations as well as the regular livestock pasturage in the highland polonynas are the principal stabilizing factors, helping to maintain the vitality of *C. heuffelianus* populations. The situation of the populations, located in the lowlands and foothills, as well as at the extreme area boundary, requires close attention. For instance, in the environs of the village of Bushtyno a population of *C. heuffelianus* has disappeared. JAKIMCHUK (1978) notes the almost complete disappearance of the species in the environs of Chernivtsy. In Transcarpathia and Precarpathia it is necessary to establish reserves in the most representative lowland sites, suffering from anthropogenic pressure. In the first place, it concerns the species localities in the environs of the major towns like Uzhgorod (the village of Tsyganivtsi), Mukachevo (Pavshyno), as well as the recreation centers, the villages of Shajan and Mala Kopanja, Transcarpathia.

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Zusammenfassung

In dem Artikel sind Ergebnisse einer bioökologischen Komplexforschung des *Crocus heuffelianus* in der Ukraine vorgestellt. Es wurden 7 Populationen in den Östlichen Karpaten (von der Ebene bis zum Alpengürtel) und 3 Populationen an der nördlichen Arealgrenze im Male Polissja (im Lemberggebiet) erforscht. Sind betont: innerartliche taxonomische Struktur, Morphologie, zwischen- und innenlichen populationsveränderungen. Es gibt hier auch eine Beschreibung des Areals, ökologischen und phytozönotischen Eigenschaften dieser Pflanzenart, ebenfalls auch die Struktur, Produktivität und Strategie erforschten Populationen. Weiter gibt es auch Angaben über den Jahressaisonrhythmus der Entwicklung Morpho- und Ontogenese, andere wichtige Aspekte der reproduktiven Biologie des *C. heuffelianus*. Dazu sind noch die Probleme des Artenschutzes und Aussichten ihrer Ausnutzung betrachtet.

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